Use Kubernetes to Create a 2-Tier Deployment

Task: Research task

Why is Kubernetes needed?

- Kubernetes is needed to automate the deployment, scaling, and management of containerized applications. It helps developers efficiently handle workloads, ensuring high availability, resilience, and resource optimization.

Benefits of Kubernetes

- Scalability: Automatically scales applications based on demand.
- High Availability: Distributes workloads to ensure application uptime.
- Resource Optimization: Efficiently manages CPU and memory utilization.
- Portability: Works across on-premises, hybrid, and multi-cloud environments.
- Self-Healing: Automatically replaces failed containers.
- Rolling Updates & Rollbacks: Ensures smooth application updates without downtime.

Sucess Stories

- Spotify: Improved scalability and developer productivity.
- Airbnb: Enhanced service availability and reliability.

Kubernetes Architecture

+---+ | Cluster | +---+ | Control Plane | | - API Server - Controller Manager | | - Scheduler - etcd | +---+ | Worker Nodes | | - Kubelet - Container Runtime (Docker, etc.) | | - Kube Proxy - Pods | +---+

What is a cluster

- A Kubernetes cluster is a set of machines running containerized applications, consisting of a control plane and worker nodes.

Master vs Worker Nodes

- Master Node: Manages the cluster, scheduling workloads, maintaining the desired state, and handling API requests.
- Worker Nodes: Run application workloads inside pods and communicate with the master node.

Managed Service vs. Self-Hosted Cluster

- Managed Service (e.g., AWS EKS, GKE, AKS):
    - Pros: Easier to set up, automated scaling, integrated security features.
    - Cons: Less customization, potential vendor lock-in.

- Self-Hosted Cluster:
    - Pros: Full control over configurations, no vendor dependency.
    - Cons: Requires manual updates, security patches, and maintenance

Control Plane vs Data Plane

- Control Plane: Manages cluster state, scheduling, and configurations.
- Data Plane: Executes workloads on worker nodes.

Kubernetes Objects:

- Deployments: Manage application deployments and updates.
- ReplicaSets: Ensure a specified number of pod replicas are running.
- Pods: The smallest deployable unit in Kubernetes, containing one or more containers.
- ConfigMaps & Secrets: Store configuration data and sensitive information.
- Ephemeral Pods:
    - Pods are designed to be temporary and can be rescheduled or restarted anytime. This means data stored within a pod is lost if not backed by persistent storage.

How to Mitigate Security Concerns with Containers

- Use Role-Based Access Control (RBAC).
- Enable network policies to limit traffic between pods.
- Scan container images for vulnerabilities.
- Run containers with the least privileges.
- Use Kubernetes-native security tools like PodSecurityPolicies.

Maintained images

- Maintained images are regularly updated and patched container base images, provided by vendors or communities.
- Pros and Cons
- Pros:
- Security patches and updates reduce vulnerabilities.
- Community or vendor support ensures reliability.
- Saves time in managing base images.
- Cons:
- May contain unnecessary dependencies.
- Vendor updates may introduce breaking changes.

Task: Get Kubernetes running using Docker Desktop

- Go into docker desktop into setting and then kubernetes
- Enable kubernetes, will install relevant packages
- To check if its working `kubectl get service`

Task: Create Nginx deployment only

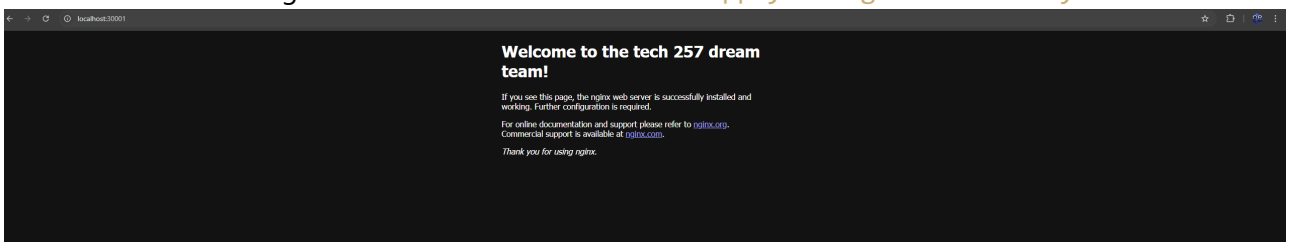
```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: daraymonsta/nginx-257:dreamteam
        ports:
        - containerPort: 80
```

- Create a nginx-deploy.yml file
- Get details of the deployment: `kubectl describe deployment <deployment-name>`
- Get details on the replicasets: `kubectl get replicasets`
- Get details on the pods: `kubectl get pods`
- Get details of all of them in one command: `kubectl get all`
- Tried to depoly it however it wasn't successful as it need to be run as a service in order for it to run

Task: Get a NodePort service running

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx-svc
spec:
  type: NodePort
  selector:
    app: nginx
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 30001
```

- Create a new yml file for the service:
- Create the service using the kubectl command `kubectl apply -f nginx-service.yml`



Task: See what happens when we delete a pod

- Check all pods first using the command specified above
- Delete one of the pods using this command: `kubectl delete pod <pod-name>`
- Go and check the pods again
- The pod is automatically replaced with a new one
- To get details of the new pod use this command `kubectl describe pod <pod-name>`

Task: Increase replicas with no downtime

Method 1: Edit the deployment file in real-time

- Step 1: `kubectl edit deployment <deployment-name>`
- Step 2: Change the replicas to 4 and save
- Step 3: Check there is now replicas by `kubectl get deployment nginx-deployment` or `kubectl get pods`

Method 2: Apply a modified deployment file

- Step 1: Change the replicas to 5 in the yml file

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  replicas: 5
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: daraymonsta/nginx-257:dreamteam
        ports:
        - containerPort: 80
```

- Step 2: Run the deployment file
- Check to see there is now 5 using the command specified before

```
tes-2- create a 2-tier-deployment (main)
$ kubectl get deployment nginx-deployment
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment   5/5     5            5           65m
```

Method 3: Use the scale command

- Step 1: Use the scale command: `kubectl get deployment nginx-deployment`
- Step 2: Check using the command earlier to confirm there is now 6.

Task: Delete K8s deployments and services

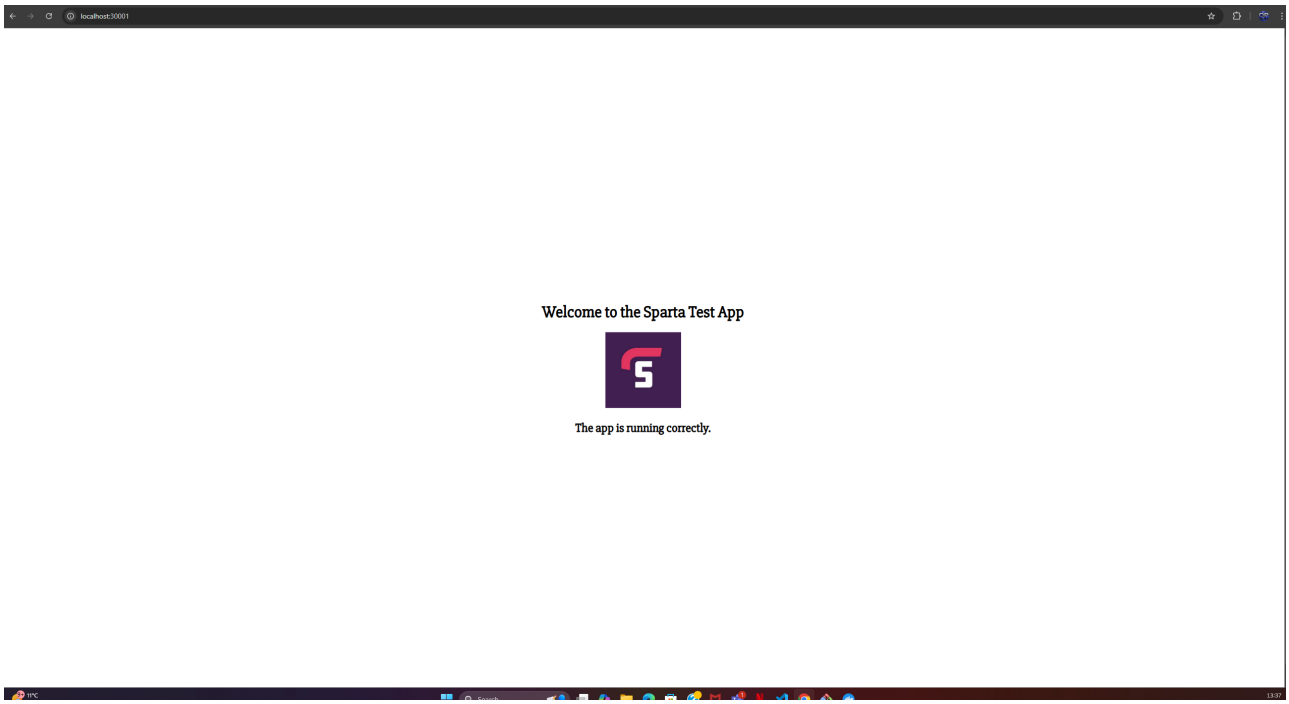
- `kubectl delete -f nginx-deployment.yml` `kubectl delete -f nginx-service.yml` to delete the deployment and service

Task: K8s deployment of NodeJS Sparta test app

- Copy the nginx files for deployment and service, change the name, ports, tags

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: sparta-app
spec:
  replicas: 5
  selector:
    matchLabels:
      app: sparta
  template:
    metadata:
      labels:
        app: sparta
    spec:
      containers:
      - name: sparta-app
        image: vineetsethi1/my-app:latest
        ports:
        - containerPort: 3000
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: sparta-service
spec:
  type: NodePort
  selector:
    app: sparta
  ports:
    - protocol: TCP
      port: 3000
      targetPort: 3000
      nodePort: 30001
```



- Create the mongodb deployment and service file

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: mongo
  labels:
    app: mongo
spec:
  replicas: 1
  selector:
    matchLabels:
      app: mongo
  template:
    metadata:
      labels:
        app: mongo
    spec:
      containers:
        - name: mongo
          image: mongo:latest
          ports:
            - containerPort: 27017
```

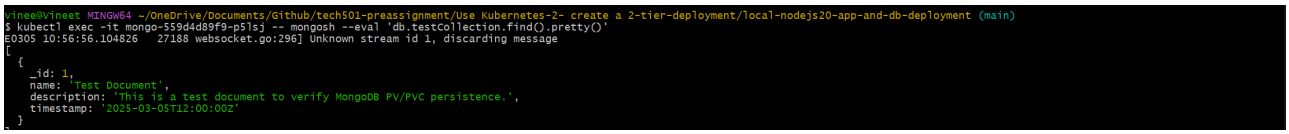
```yaml
apiVersion: v1
kind: Service
metadata:
  name: mongo
spec:
  selector:
    app: mongo
  ports:
    - protocol: TCP
      port: 27017
      targetPort: 27017
```

- Make sure to create the environment variable in the sparta-app-deploy file
- I was getting the posts page up and, however there wasn't any content on their, which therefore meant it needed to be seeded. Used this command `kubectl exec -it <sparta-app-pod> -- bash` and then npm install to seed the db

Task: Create 2-tier deployment with PV for database

- Created a pv and pvs yml file with the relevant storage allocation
- Made change to the mongo yml file as well to make sure it links to pv/pvc
- Insert test documentation in the mongo pod `kubectl exec -it mongo-559d4d89f9-k8tcx -- mongosh --eval 'db.testCollection.insertOne({_id: 1, name: "Test Document", description: "This is a test document to verify MongoDB PV/PVC persistence.", timestamp: "2025-03-05T12:00:00Z"})'`

- Verify its there `kubectl exec -it mongo-559d4d89f9-k8tcx -- mongosh --eval 'db.testCollection.find().pretty()'`
- Delete the pod, which will then get replaced with a new one automatically
- Get the name of the new pod
- Now check to see if the documentation is still there in the new pod `kubectl exec -it mongo-559d4d89f9-p5lsj -- mongosh --eval 'db.testCollection.find().pretty()'`
- If it is there, then it has been successful and works



Task: Research types of autoscaling with K8s

- There are three different methods of Kubernetes autoscaling:
  - Horizontal Pod Autoscaler (HPA)
  - Vertical Pod Autoscaler (VPA)
  - Cluster Autoscaler (CA)

Task: Use Horizontal Pod Autoscaler (HPA) to scale the app

- Step 1: Create the metric server yml file which will allow download for the pod to be created without having to worry about permissions
- Step 2: In the Sparta- app deployment yml file add resource element
- Step 3: Create the autoscale using this command `kubectl autoscale deployment my-app --cpu-percent=50 --min=2 --max=10`
- Step 4: Install load tester
- Step 5: Run the load tester on a loop
- Step 6: Monior the scale behaviour: `kubectl get hpa -w # Watch HPA status`

```
vinee@Vineet MINGW64 /C/Users/vinee/OneDrive/Documents/Github/tech501-preassignment/Use Kubernetes
-2- create a 2-tier-deployment/local-nodejs20-app-and-db-deployment (main)
$ kubectl apply -f metric-server.yml
deployment.apps/metrics-server created

vinee@Vineet MINGW64 /C/Users/vinee/OneDrive/Documents/Github/tech501-preassignment/Use Kubernetes
-2- create a 2-tier-deployment/local-nodejs20-app-and-db-deployment (main)
$ kubectl get hpa -w  # Watch HPA status
NAME         REFERENCE               TARGETS              MINPODS   MAXPODS   REPLICAS   AGE
sparta-app   Deployment/sparta-app   cpu: <unknown>/50%   2         10        3          58m


vinee@Vineet MINGW64 /C/Users/vinee/OneDrive/Documents/Github/tech501-preassignment/Use Kubernetes
-2- create a 2-tier-deployment/local-nodejs20-app-and-db-deployment (main)
$ kubectl get deployments -A


NAMESPACE     NAME             READY   UP-TO-DATE   AVAILABLE   AGE
default       mongo            1/1     1            1           70m
default       sparta-app       3/3     3            3           62m
kube-system   metrics-server   1/1     1            1           74s

vinee@Vineet MINGW64 /C/Users/vinee/OneDrive/Documents/Github/tech501-preassignment/Use Kubernetes
-2- create a 2-tier-deployment/local-nodejs20-app-and-db-deployment (main)
$ kubectl get hpa -w  # Watch HPA status
NAME         REFERENCE               TARGETS       MINPODS   MAXPODS   REPLICAS   AGE
sparta-app   Deployment/sparta-app   cpu: 0%/50%   2         10        3          60m
sparta-app   Deployment/sparta-app   cpu: 0%/50%   2         10        2          61m
sparta-app   Deployment/sparta-app   cpu: 104%/50%   2         10        2          66m
```

- Use this command to delete the metric server when done `kubectl delete deployment metrics-server -n kube-system`

Task: Setup minikube on a cloud instance running Ubuntu 22.04 LTS

- Step 1: Install minikube
  - `curl -Lo minikube https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64 \ && chmod +x minikube`
  - `sudo mkdir -p /usr/local/bin/ sudo install minikube /usr/local/bin/`
  - Install docker: `sudo apt install -y apt-transport-https ca-certificates curl software-properties-common`
    - `curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/docker-archive-keyring.gpg`
    - `echo "deb [arch=amd64 signed-by=/usr/share/keyrings/docker-archive-keyring.gpg] https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null`
    - `sudo apt update sudo apt install -y docker-ce`
    - `sudo systemctl start docker sudo systemctl enable docker`
  - To give permissions an get access to docker daemon:
    - `sudo usermod -aG docker $USER`
    - `newgrp docker`
  - Run the command `minikube start --driver=docker` and it will now run minikube
  - Check to see if minikube is working `minikube status`

Task: Deploy on three apps on one cloud instance running minikube

- Step 1: Install nginx
- Step 2: Configure reverse proxy
  - `sudo nano /etc/nginx/sites-available/default`

```
server {
 listen 80;

 location /app1 {
     proxy_pass http://192.168.49.2:30001/;
 }

 location /app2 {
     proxy_pass http://localhost:9000;
 }

 location /app3 {
     proxy_pass http://localhost:8080;
 }
}
```

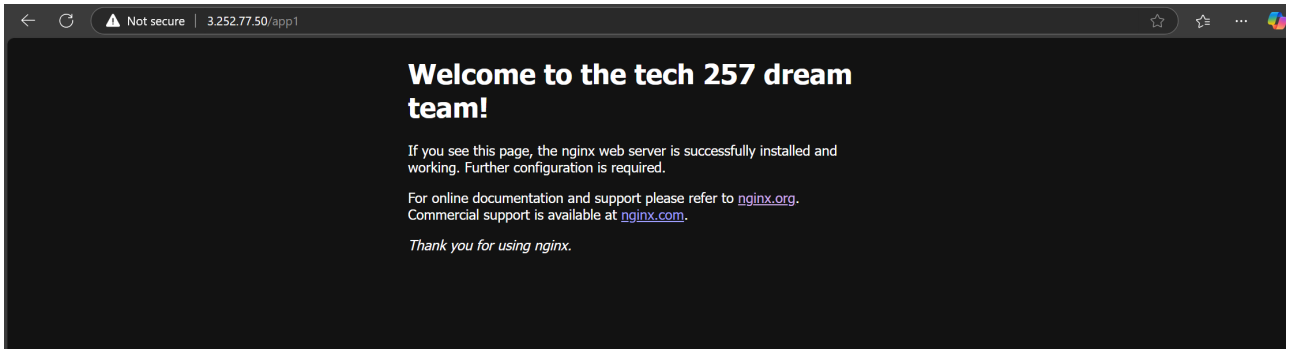
- Had issues configuring the nginx page I had to change the ip to the minikube ip and add an `/` at the end of the 30001 as the app might not be handling root (/) requests.

- Step 3: Create a yml file for app1 deployment and service

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: app1-deployment
spec:
  replicas: 5
  selector:
    matchLabels:
      app: app1
  template:
    metadata:
      labels:
        app: app1
    spec:
      containers:
      - name: app1-container
        image: daraymonsta/nginx-257:dreamteam
        ports:
        - containerPort: 80
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: app1-service
spec:
  selector:
    app: app1
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
      nodePort: 30001
  type: NodePort
```

- Step 4: Execute the files
- Step 5: Go to the public ip of the vm in the browser followed up with app1. So something like this `http://3.252.77.50/app1`



- Step 6: Create a new yml file for the app2 deployment and service

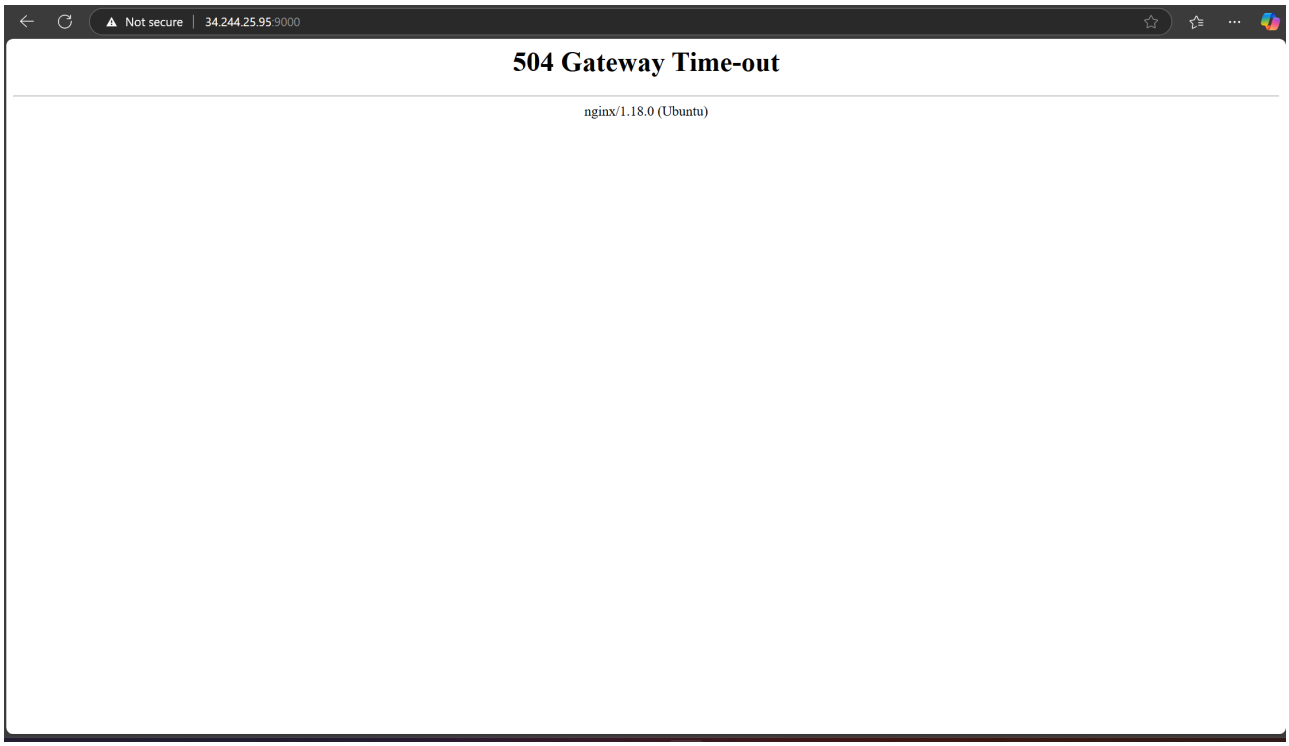
```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: app2-deployment
spec:
  replicas: 2
  selector:
    matchLabels:
      app: app2
  template:
    metadata:
      labels:
        app: app2
    spec:
      containers:
      - name: app2-container
        image: daraymonsta/tech201-nginx-auto:v1
        ports:
        - containerPort: 80
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: app2-service
spec:
  selector:
    app: app2
  ports:
    - protocol: TCP
      port: 9000
      targetPort: 80
      #nodePort: 30002
  type: LoadBalancer
```

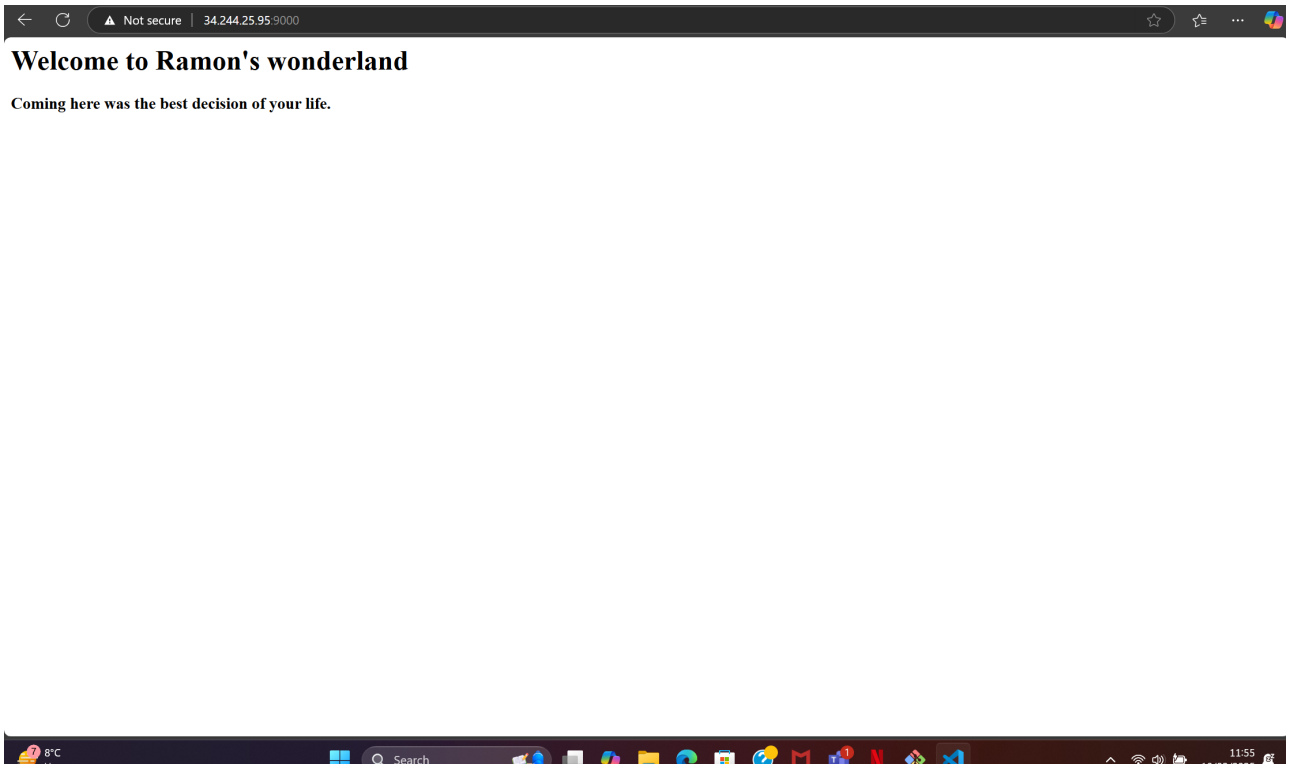
```
server {
    listen 9000;
    server_name _;

    location / {
        proxy_pass http://10.105.184.153:9000;
        proxy_set_header Host $host;
        proxy_set_header X-Real-IP $remote_addr;
        proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
        proxy_set_header X-Forwarded-Proto $scheme;
    }
}
```

- Step 7: Test to see it works by turning the minikube tunnel on and it should load the page



```
^Cubuntu@ip-172-31-54-100:~$ minikube tunnel
Status:
        machine: minikube
        pid: 32131
        route: 10.96.0.0/12 -> 192.168.49.2
        minikube: Running
        services: [app2-service]
    errors:
                minikube: no errors
                router: no errors
                loadbalancer emulator: no errors
```



Task: Use Kubernetes to deploy the Sparta test app in the cloud

- Steps are the same as the setting it up earlier
- Step 1: Install minikube
  - `curl -Lo minikube https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64 \ && chmod +x minikube`
  - `sudo mkdir -p /usr/local/bin/ sudo install minikube /usr/local/bin/`
  - Install docker: `sudo apt install -y apt-transport-https ca-certificates curl software-properties-common`
    - `curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/docker-archive-keyring.gpg`
    - `echo "deb [arch=amd64 signed-by=/usr/share/keyrings/docker-archive-keyring.gpg] https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null`
    - `sudo apt update sudo apt install -y docker-ce`
    - `sudo systemctl start docker sudo systemctl enable docker`
  - To give permissions an get access to docker daemon:
    - `sudo usermod -aG docker $USER`

        - `newgrp docker`
    - Run the command `minikube start --driver=docker` and it will now run minikube
    - Check to see if minikube is working `minikube status`

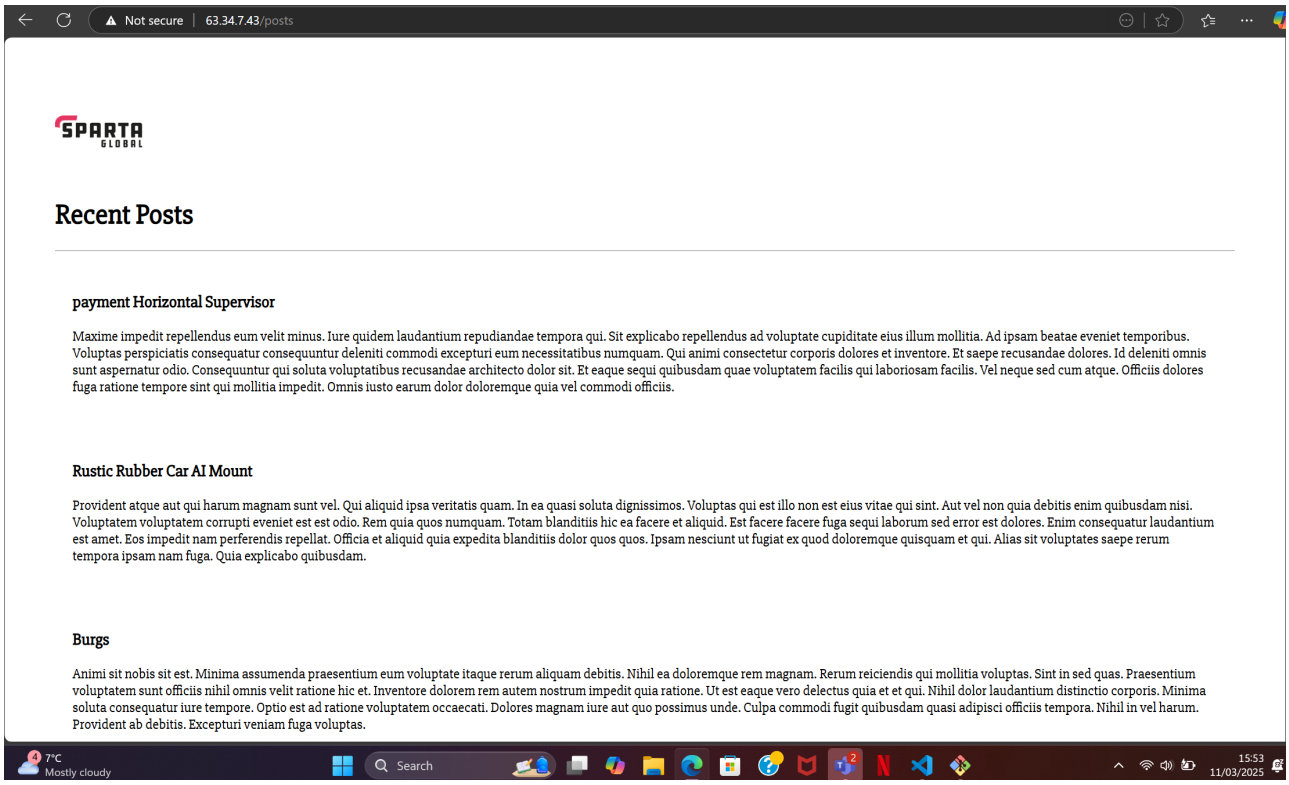
- Step 2: Make sure you have all the deployment files such as the ones for sparta-app.deploy, sparta-app-service, mongo-pv.yml, mongo-pvc.yml, mongo-deploy.yml, mongo-service.yml, metric-server.yml, hpa.yml

- Go into the reverse proxy file and make sure your working with minikube ip

```
server_name _;

location / {
        # First attempt to serve request as file, then
        # as directory, then fall back to displaying a 404.
        proxy_pass http://192.168.49.2:30001;
}
```

- Make sure you get sparta posts page working first with minikube before doing the hpa



- hpa.yml:

```
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: sparta-hpa
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: sparta-app
  minReplicas: 2
  maxReplicas: 10
```

```
    metrics:
      - type: Resource
        resource:
          name: cpu
          target:
            type: Utilization
            averageUtilization: 40
```